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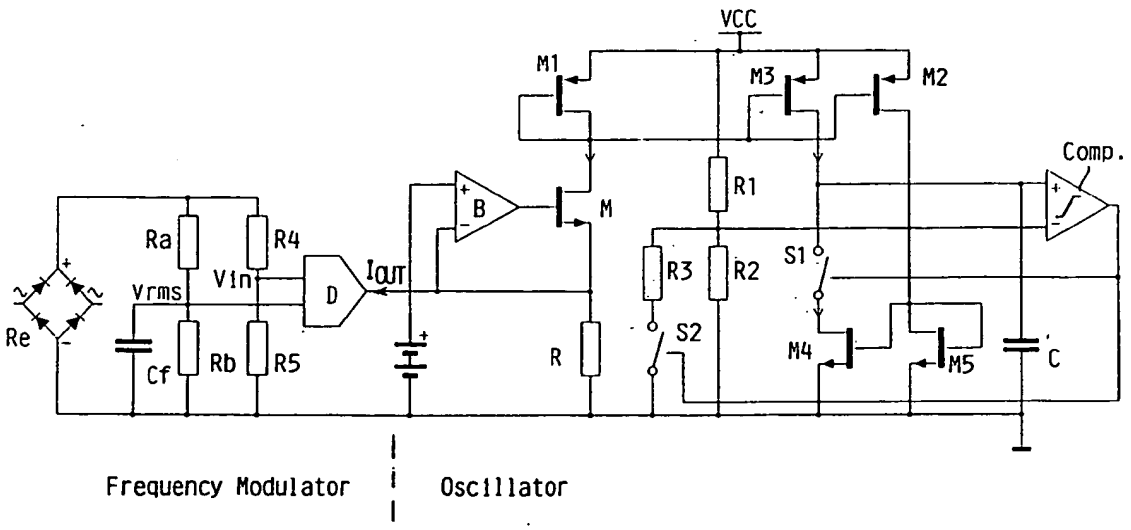
(54) Frequency modulated switching power supply.

(57) A switching-type power supply circuit for direct connection to an AC outlet is provided with a circuit for modulating the switching frequency in an inversely proportional relationship with the instantaneous amplitude of the rectified RC voltage, suitably "normalized" in relation to its effective RMS value. By reducing the switching frequency under conditions of relatively high switching current, attenuates the switching noise and reduces power losses.



EP 0 580 919 A1

The present invention relates to a switching power supply circuit for direct connection to an AC power outlet and more in general to a frequency modulator circuit which is particularly suited for modulating the switching frequency of a power supply in function of the instantaneous value of a rectified AC voltage.

The so-called switching type power supplies are widely used circuits in electronic and electromechanical appliances for providing a low-voltage DC supply of electronic circuits through a rectifier circuit which may be directly connected to the AC power outlet without using a step-down transformer. The absence of a transformer and the mode of operation of a switching-type power supply circuit causes the generation of electromagnetic disturbances which propagate through the AC power distribution network. The main frequency of these disturbances which is related to the switching frequency of the power supply circuit may have a value which interferes with telecommunication systems using the power distribution lines as signal path and may also cause problems in other electronic apparatuses, connected to the AC power distribution network.

Commonly the oscillator employed for determining a certain oscillation frequency of a switching-type power supply circuit, i.e. for driving a power switch of the circuit, comprises a ramp generating circuit, the output ramp signal of which is fed to an input of a comparator. To another input of the comparator a reference voltage is applied in order to determine a certain triggering threshold of the comparator, which drives the charge and discharge switches of a capacitance of the ramp generator. The oscillation frequency is normally preestablished by selecting a value of capacitance and/or resistance suitable to determine a certain RC characteristic for the charge and discharge processes. Moreover, the ramp generator circuit commonly utilizes a constant current generator, that may be composed of a buffer capable of forcing a certain constant current through a resistance. The constant current so generated is mirrored in a charge/discharge network of the capacitor of the ramp generator circuit.

It has now been found and is an object of the present invention, that by "modulating" the oscillation frequency so as to have an instantaneous frequency value which is inversely proportional to the instantaneous amplitude of the rectified RC voltage (i.e. a low frequency of oscillation when the instantaneous value of the rectified AC voltage is high and therefore also the current which flows through the power switch is high and viceversa) has a decisive effect in attaining two important results. Firstly, by reducing the oscillation frequency when conditions of high switching current persist, the energy associated with electromagnetic disturbances which are transmitted through the AC power distribution network is greatly reduced. Secondly, a reduction of the oscillation frequency when the switching current is relatively high reduces power losses through the power switch. In other words, by reducing the switching frequency when conditions of a high switching current persist, a net improvement of the performance of the power supply circuit and an attenuation of the noise produced are obtained.

In accordance with a preferred embodiment of the present invention, the modulation of the oscillation frequency, in function of the instantaneous value of the rectified AC voltage, of an oscillator circuit comprising a voltage ramp generator, takes place by employing a divider circuit having two inputs and an output. To a first input thereof, a signal representative of the intantaneous AC voltage, e.g. of the AC voltage as recified by a normal bridge rectifier, is applied. To the other input of the divider circuit a voltage representative of the RMS value of the rectified AC voltage, as easily obtained on the output node of a low-pass filter which may be connected across the output nodes of the bridge rectifier, is applied. As it is well known, a so-called divider is a circuit capable of generating through an output node a current given by: $I_{OUT} = K(|V_{ist}|/V_{RMS})$. This output current ($I_{OUT}$) generated by the divider circuit is utilized for modulating the oscillation frequency of the oscillator and has an instantaneous value which is proportional to the instantaneous value of the rectified AC voltage (V_{ist}), "normalized" as referred to its RMS value (V_{RMS}). Therefore, the value of the output current I_{OUT} advantageously depends only on the design parameters of the circuit and is independent of the actual RMS value of the AC voltage, which notably may vary from country to country. The output node of the frequency modulating circuit (i.e. of the divider circuit) may be directly connected to the resistance used in the current generator circuit of the ramp generator circuit of the oscillator, in order to substract from the charge/discharge current of the capacitance of the ramp generator a variable current (I_{OUT}) generated by the modulating circuit in function of the instantaneous value of the rectified AC voltage.

The different aspects and advantages of the invention will become more evident through the description of an embodiment thereof and by referring to the annexed drawing which reproduces a functional circuit diagram of a modulator circuit object of the present invention coupled to a voltage ramp oscillator which is commonly used in switching power supplies.

With reference to the figure, a typical oscillating circuit (OSCILLATOR) commonly used in

switching-type power supplies, is composed of a voltage ramp generating circuit and a comparator COMP, the triggering threshold of which may be established by means of a voltage divider formed by R1 and R2. The ramp generator circuit comprises a capacitance C, which may be charged by the current delivered by the transistor M3 and discharged through a discharge path, controlled by a switch S1 driven by the comparator COMP, by the current delivered by the transistor M4. The frequency of oscillation may be adjusted by establishing a certain charge and discharge current of the capacitance C and this is commonly achieved by utilizing a constant current generator which, as shown, may be composed of a buffer B capable of controlling a transistor MO, which forces a certain current through a resistance R, the value of which may be chosen in function of the desired frequency of oscillation. Such a pre-defined current is mirrored through the transistors M1, M2 and M5 on the charge and discharge transistors M3 and M4 of the capacitance C, respectively. A second switch, S2, driven by the comparator COMP, has the purpose of connecting R3 in parallel with R2 in order to lower the triggering threshold of the comparator COMP to a certain level of the voltage ramp.

According to a preferred embodiment of the invention, the frequency of oscillation so pre-defined, is modulated in function of the instantaneous value of the rectified AC voltage by employing a frequency modulating circuit (FREQUENCY MODULATOR) composed essentially of a divider circuit, D, having two inputs. A first input (V_{in}) is connected to an intermediate node of a voltage divider formed by the resistances R4 and R5, which is connected across the output nodes of a bridge rectifier, Re, which may be directly connected to the AC outlet. A second input is connected to the output node (V_{RMS}) of a low-pass filter, formed by the network which comprises Ra, Rb and Cf, connected across the output nodes of the bridge rectifier Re. The divider circuit D produces on its output node, an output current which is given by: $I_{OUT} = K(|V_{in}|/V_{RMS})$, where V_{in} isa signal having the same wave form of the rectified AC voltage and V_{RMS} is a voltage representative of the RMS value of the AC voltage.

The current I_{OUT} produced by the frequency modulator circuit is subtracted to said pre-established charge/discharge current of the capacitance C and therefore, "modulates" the frequency of oscillation between a maximum value (which will correspond to the nominal frequency of oscillation as established by the design of the oscillator circuit) and a minimum value which may be also easily pre-defined and which is reached in coincidence with peak values of the modulating current I_{OUT} produced by the frequency modulator circuit. Therefore, the frequency of oscillation will be variable and notably inversely proportional to the instantaneous value of the rectified AC voltage as normalized in respect to its RMS value.

In this way, the modulating current I_{OUT} produced by the frequency modulator circuit of the invention will have a value which depends exclusively from circuital design parameters and not by the actual RMS value of the AC voltage. Therefore, the switching power supply having a modulated frequency in accordance with the present invention, may be used in different locations also having different AC power distribution standards (e.g. European countries and United States) without any alteration of performance.

Beside the above noted advantages of attenuating the disturbances which are produced by a switching power supply circuit on the AC network and of reducing power losses, the circuit of the invention may be easily "retrofitted" to an existing oscillator circuit, without the need of redesigning the oscillator circuit. The maximum frequency of oscillation may remain the same as determined by an existing oscillator circuit, while the minimum frequency of oscillation, which is achieved by means of the modulating circuit of the invention, will depend exclusively by circuit design parameters and therefore may be easily pre-determined according to need.

Claims

1. A switching-type power supply for direct connection to an AC power distribution network, characterized by having a switching frequency which is inversely proportional to the instantaneous amplitude of a rectified AC voltage.

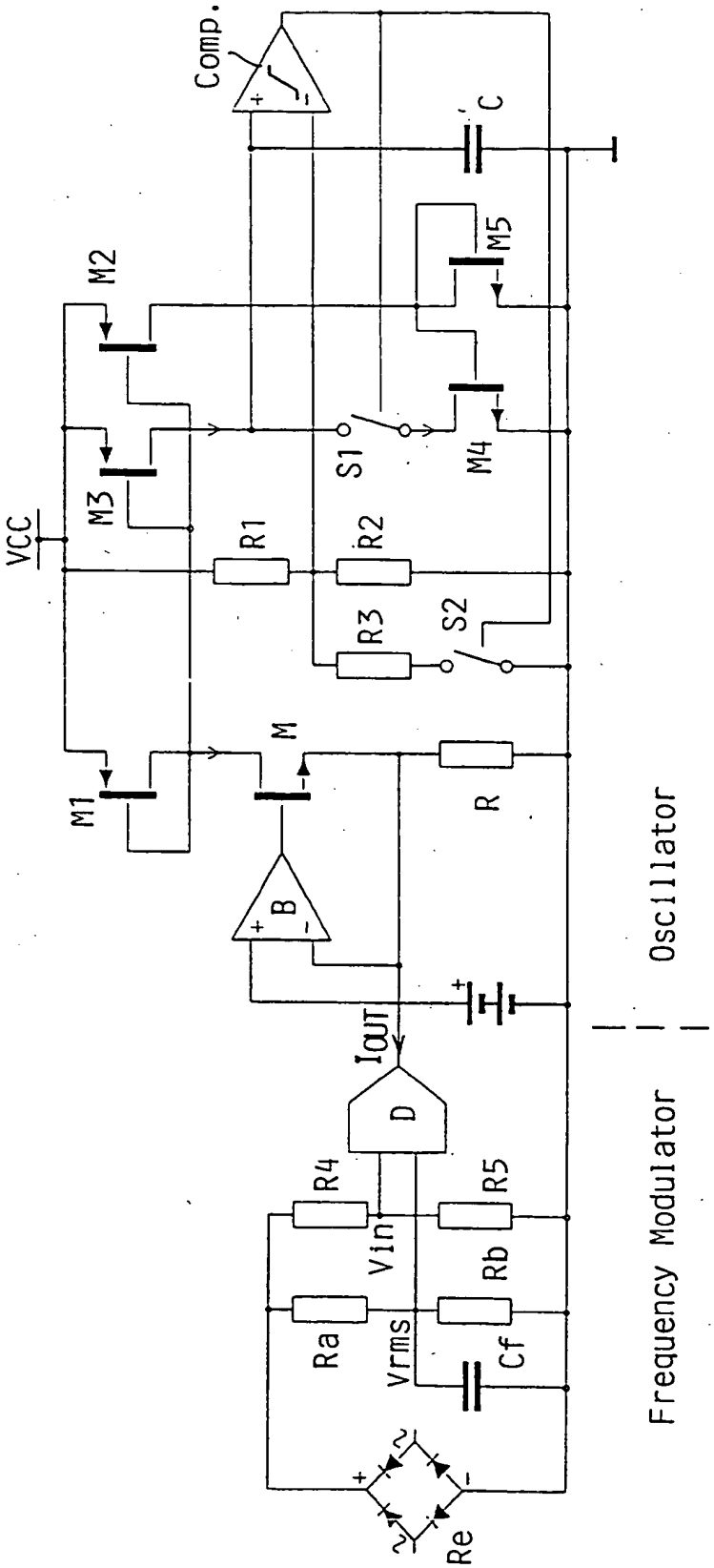
2. A switching-type power supply for direct connection to an AC power distribution network, comprising a voltage ramp type oscillator, the frequency of oscillation of which is determined by a charge current and a discharge current of a capacitance, characterized by comprising

   a circuit capable of varying said charge and discharge currents in an inversely proportional relationship with the instantaneous amplitude of a rectified AC voltage, thus modulating said oscillation frequency in an inversely proportional relationship with said instantaneous amplitude of the rectified AC voltage of said distribution network.

3. A switching-type power supply as defined in Claim 2, wherein said circuit comprises a divider circuit having a first and a second input and an output, the first input being connected to the output node of a low-pass filter con-

nected in cascode to a rectifier circuit of said AC voltage, the second input being connected to an intermediate node of a voltage divider functionally connected to the output of said rectifier circuit and the output node being functionally connected to the output node of a generator of said charge and discharge currents;

said circuit producing through said output a current proportional to a signal representative of the instantaneous value of the rectified AC voltage, present on said first input, divided by a voltage representative of an RMS value of said AC voltage, present on said second input.


Comp.
C
M5
M2
M4
S1
M3
VCC
R1
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M1
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B
Iout
D
R4
R5
Vin
Rb
Ra
Vrms
Cf
Re
Oscillator
Frequency Modulator

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 92 83 0418

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X Y	WO-A-8 501 400 (MINITRONICS) * page 8, line 2 - line 6; figures 4,6 *	1 2	H02M3/156
Y A	US-A-3 946 330 (TAKAHASHI) * the whole document *	2 3	
X	EP-A-0 223 315 (PHILIPS) * column 2, line 29 - line 50; figures 1,2 *	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

H02M
H03K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	24 MARCH 1993	GENTILI L.

CATEGORY OF CITED DOCUMENTS

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